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Indian Standard

SOLAR PHOTOVOLTAIC ENERGY SYSTEMS — TERMINOLOGY

भारतीय मानक

सौर फोटोवोल्टीय ऊर्जा प्रणाली — पारिभाषिक शब्दावली

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Solar Photovoltaic Energy Systems Sectional Committee, ETDC 68

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 8 November 1989, after the draft finalized by the Solar Photovoltaic Energy Systems Sectional Committee had been approved by the Electrotechnical Division Council.

Considerable progress has been made by the concerned agencies in this country in harnessing solar energy for the betterment of rural Life. Solar Photovoltaics power technology particularly, has considerable scope in areas where transport of electrical energy by conventional means is not cost effective. Production and development of photovoltaic systems in Stand-alone or grid connected modes has been gradually on the increase thereby necessitating the need for national standards that would guide the technical and quality parameters of components and sub-systems. There is also a need to prepare standards on methods of evaluation of photovoltaic system parameters and associated characteristics that would enable purchasers to assess the degree of performance that could be expected out of a design.

This Indian Standard is one amongst the first series of standards finalized by the Solar Photovoltaic Energy Systems Sectional Committee, ETDC 68.

This Indian Standard is based on Doc : IEC/TC 82 (Prague) 10 Glossary of terms, issued by the International Electrotechnical Commission (IEC).

In due course of time, on establishing that the terms and their definitions covered in this standard are widely accepted, this standard would be included in IS 1885 (series) Electrotechnical vocabulary.

Indian Standard

SOLAR PHOTOVOLTAIC ENERGY SYSTEMS — TERMINOLOGY

1 SCOPE

1.1 This Standard covers definition of terms used in the area of solar photovoltaic energy systems.

2 TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Air Mass (AM)

The length of path through the earth's atmosphere traversed by the direct solar beam, expressed as a multiple of the path traversed to a point at sea level with the sun directly overhead.

NOTE — The value of air mass is 1 at sea level with cloudless sky when the sun is directly overhead and the air pressure $P = 1\cdot013$ bar (760 mm Hg). At any point, the value of the air-mass is given by:

$$AM = \frac{P}{P_0} \times \frac{1}{\text{Sin}\theta}$$

where P is the local air pressure in bar; $P_0 = 1\cdot013$ bar and θ is the solar elevation angle.

2.2 Ambient Temperature (T_{amp})

The temperature of the air surrounding the photovoltaic device as measured by a thermometer in a vented enclosure and shielded from solar, sky and ground radiation.

2.3 Angle of Incidence (degrees)

The angle between the direct irradiant beam and the normal to the active surface.

2.4 Array (*see* Fig. 1)

A mechanically integrated assembly of modules or panels together with support structure but exclusive of foundation, tracking, thermal control and other such components, to form a DC power producing unit.

2.5 Array Area

The entire frontal area of the array including the area covered by the modules, the inter-module spacing and frame work.

2.6 Array Field (*see* Fig. 1)

The aggregate of all solar photovoltaic arrays within a given system.

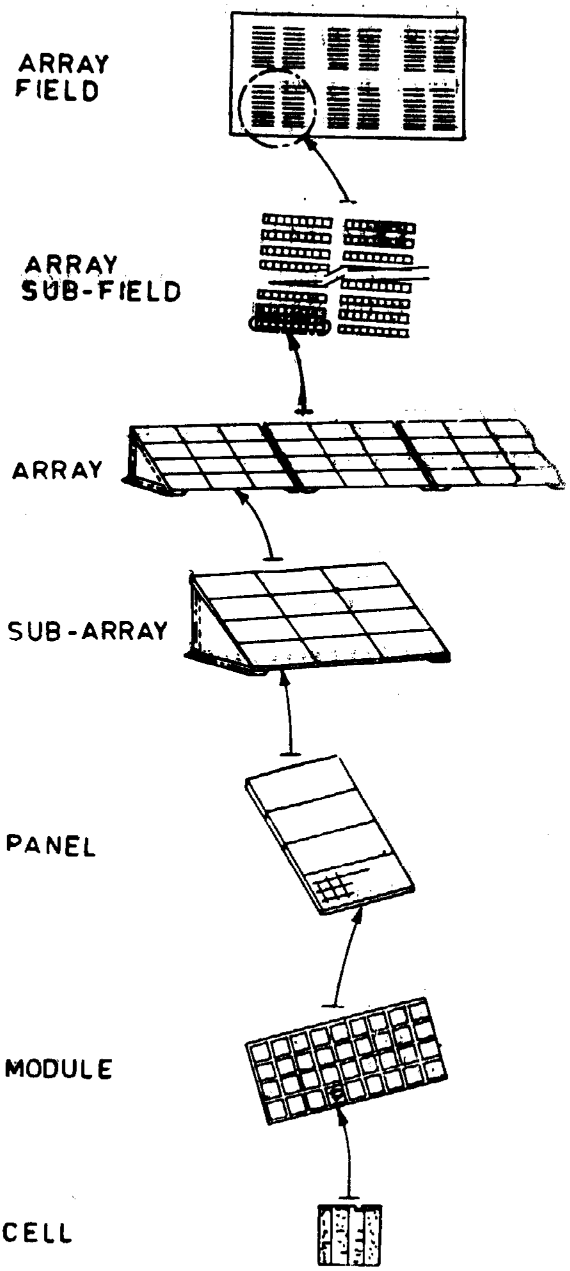

FIG. 1 DIAGRAMATIC EXPLANATION OF CERTAIN TERMS DEFINED

2.7 Array Field Site

The entire area required to accommodate the array, array foundation, tracking thermal control, and other such components. The area is also inclusive of internal roads, inter array spacing, and the space between the array and the site boundary.

2.8 Array Interface

The point at which the array or array simulator is connected to the power Conditioning Sub-system.

2.9 Array Sub-field (*see* Fig. 1)

A group of solar photovoltaic arrays associated by a distinguishing feature such as a physical arrangement, or electrical interconnection or power conditioning.

2.10 Array Sub-system

The aggregate of the array, the array foundation, tracking, thermal control, and all other such components.

2.11 Battery End-of-Charge Voltage

The voltage at which the charge is normally terminated by the charging source.

2.12 Battery Final (Cut Off) Voltage

The prescribed voltage at which the discharge is considered complete for a particular capacity rating and discharge rate.

2.13 Blocking Diode

A diode connected in series with module(s) or panel(s) to prevent reverse current in such module(s) or panel(s).

2.14 Bypass (or Shunt) Diode

A diode connected in the forward current direction across one or more cells, modules, or panels to allow current to bypass such cells, modules, or panels.

2.15 Cell Grid

The contact that is used to collect electricity from the surface of the solar cell.

2.16 Cell Temperature (T_j)

The temperature of the cell junction as directly measured by a thermal sensor in contact with the cell or derived from V_{OC} measurement or thermal balance calculations. It is not very different from the temperature of the cell exposed face.

2.17 Commutation

The action of transferring current from one switching device to another in a power conditioning unit.

NOTE — Stand-alone inverters must be self-commutated but utility interactive inverters may make use of line commutation where the circuit operation depends on the utility line connection. Utility interactive inverters may also be self-commutated. Other types of commutation have been used, such as natural and load commutation but generally in special applications.

2.18 Conversion Efficiency

The ratio of maximum electrical power output to the product of photovoltaic device area and incident irradiance measured under defined test conditions and expressed as a percentage.

2.19 Current Temperature Coefficient (α)

The change of the short-circuit current of the photovoltaic device per degree celsius change of cell temperature.

NOTE — This coefficient varies with irradiance and to a lesser extent, with temperature.

2.20 Current-Voltage Characteristic [$I = f(V)$]

The output current of a photovoltaic device as a function of output voltage at a particular temperature and irradiance.

2.21 Electric Utility

Generally, an organization responsible for the installation, operation and maintenance of major electric supply and distribution systems.

2.22 Fill Factor (*FF*)

The ratio of maximum power to the product of open-circuit voltage and short-circuit current:

$$FF = \frac{P_{max}}{V_{OC} \times I_{SC}}$$

2.23 Inverter

A device which changes DC input into an AC output.

2.24 Inverter Efficiency

The ratio of the useful electrical output power of the inverter to the power input.

2.25 Irradiance

(Wm^{-2}) radiant power incident upon unit area of surface.

2.26 Irradiance, Direct (Wm^{-2})

The radiant power from the sun's disc and from a small circumsolar region of the sky within a subtended angle of 5° incident upon unit area.

2.27 Irradiance, Diffuse (Wm^{-2})

The total radiant power incident upon a unit area excluding the direct irradiance.

2.28 Irradiance, Global (Wm^{-2})

Total radiant power incident upon unit area of a horizontal surface-direct irradiance (horizontal) plus diffuse irradiance (horizontal).

2.29 Irradiance, Spectral (Spectro) Photon ($N\lambda$)

Photon flux density at a particular wavelength ($Wm^{-2}\,s^{-1}\,\mu m^{-1}$).

2.30 Irradiance Spectral (Spectro) ($E\lambda$)

Irradiance per unit bandwidth at a particular wavelength (Wm^{-2}, μm^{-1}).

2.31 Irradiance, Total (Wm^{-2})

Total radiant power incident upon a unit area of an inclined surface.

2.32 Irradiation (Insolation)

Integration of irradiance over a specified period of time. (MJm^{-2} per hour, day, week, month, year as the case may be).

2.33 Irradiation (Insolation), Direct

Integrated direct irradiance over a specified time period. (MJm^{-2} per hour, per day, as the case may be).

2.34 Irradiation (Insolation), Global

Integrated global irradiance over a specified time period. (MJm^{-2} per hour, per day, etc, as the case may be).

2.35 Irradiation (Insolation), Diffuse

Integrated diffuse irradiance over a specified time interval. (MJm^{-2} per hour, per day, etc, as the case may be).

2.36 Irradiation (Insolation), Total

The integrated total irradiance over a specified time interval on a tilted surface. (MJm^{-2} per day, week, etc, as the case may be).

2.37 Junction Temperature

See Cell Temperature.

2.38 Load Current (I_L)

The current supplied by the photovoltaic device into a load connected across its terminals at a particular temperature and irradiance.

2.39 Load Power (P_L)

The power supplied to a load connected to the terminals of the PV device at a particular temperature and irradiance.

2.40 Load Voltage (V_L)

The voltage appearing across the terminals of a load connected to the terminals of the photovoltaic device at a particular temperature and irradiance.

2.41 Monitor and Control Sub-system

Logic and control circuitry which supervises the overall operation of the system by controlling the interaction between all sub-systems.

2.42 Maximum Power (P_{max})

The power at the point on the current voltage characteristic curve where the product of current and voltage is a maximum at a particular temperature and irradiance.

2.43 Maximum Power Current (I_{Pmax})

The current corresponding to maximum power.

2.44 Maximum Power Tracking

A control strategy whereby system operation is always at or near the maximum power point of the photovoltaic device.

2.45 Maximum Power Voltage (V_{Pmax})

The voltage corresponding to maximum power.

2.46 Maximum System Open Circuit Voltage

The sum of the maximum open circuit voltages of the maximum number of modules of panels to be connected in series in a system.

2.47 Mismatch Efficiency

The ratio of the output of a series/parallel assembly of cells or modules measured in uniform irradiance conditions to the aggregate of the outputs of the individual elements calculated for the same irradiance and temperature. (Includes inter-connected series resistance losses).

2.48 Module (*see* Fig. 1)

The smallest complete environmentally protected assembly of interconnected solar cells.

2.49 Module Area

The entire frontal area (m^2) of the module, including borders and frame.

2.50 Module Packaging Efficiency

The ratio of the total cell area to module area.

2.51 Module Surface Temperature

The mean temperature of the back surface of the module.

2.52 NOCT Efficiency (η_{NOCT})

The ratio of the module efficiency at NOCT to the module efficiency at the standard cell temperature of 25°C.

2.53 NOCT (Nominal Operating Cell Temperature)

The equilibrium mean solar cell temperature within a module in a standard reference environment of 800 Wm^{-2} irradiance, 20°C ambient air temperature, and 1 ms^{-1} wind speed, electrically open-circuited and open-rack mounted at normal incidence to the sun at solar noon.

2.54 Open Circuit Voltage (V_{OC})

The voltage across an unloaded (open) photovoltaic device at a particular temperature and irradiance.

2.55 Optional Test Conditions (OTC)

Irradiance = 1 000 Wm^{2} with the reference solar spectral irradiance distribution. Cell temperature = any convenient measured ambient conditions.

2.56 Ozone Content

The volume of ozone (cm^{3}) at standard temperature and pressure in a vertical column of the atmosphere 1 cm^{2} in cross section.

2.57 Panel (*see* Fig. 1)

A group of modules fastened together, preassembled and wired, designed to serve as an installable unit in an array and/or sub-array.

2.58 Panel Area (m^{2})

The entire frontal area of the panel, including modules, intermodule framework and spacing.

2.59 Panel Packing Efficiency

The ratio of the total module area to panel area.

2.60 Photovoltaic Effect

Direct conversion of radiant energy into electrical energy.

2.61 Photovoltaic (PV) System

An installed aggregate of components and subsystems that combine to use the photovoltaic effect to convert solar energy into electrical energy suitable for connection to an application load. In its simplest form a photovoltic system consists of a photovoltaic array with connections to the load, but it may also include power conditioning monitoring and control equipment, energy storage and power distribution units.

2.62 Photovoltaic-System/Utility Interface

The interconnection between the power conditioning sub-system, and the utility.

2.63 Power Conditioner

The electrical equipment used to convert electrical power into a form or forms of electrical power suitable for subsequent use.

2.64 Precipitable Water Vapour Content

The volume of precipitable water vapour (cm^{-3}) in a vertical column of the atmosphere 1 cm^{2} in cross section expressed as the height of the corresponding vertical column of water (cm).

2.65 Pyranometer

A radiometer normally used to measure global solar irradiance (or, with a shade ring or disc, diffuse solar irradiance) on a horizontal plane, can also be used at an angle to measure the total irradiance on an inclined plane, which in this case includes a contribution due to radiation reflected from the foreground.

2.66 Pyrheliometer

(Sometimes called 'Normal Incidence Pyrheliometer' or NIP). A Radiometer, complete with a collimeter, used to measure direct solar irradiance.

2.67 Rated Current

The measured value of current of a photovoltaic device at rated voltage under Specified Operating Conditions.

2.68 Rated Maximum Power

The value of maximum power of a photovoltaic device under Specified Operating Conditions.

2.69 Rated Power

The value of power output of a photovoltaic device at rated voltage under Specified Operating Conditions.

2.70 Rated Voltage

The voltage at which a photovoltaic device is designed to produce near maximum electrical power under Specified Operating Conditions.

2.71 Reference Solar Cell

A solar cell used to measure irradiance or to set simulator irradiance levels in terms of a reference solar spectral (spectro) irradiance distribution.

2.72 Reference Spectral (Spectro) Irradiance Distribution

The spectral (spectro) irradiance distribution to be used for reference purposes in photovoltaic measurements as defined in the relevant IEC standard.

2.73 Short-Circuit Current (I_{SC})

The output current of a photovoltaic device in the short-circuit condition at a particular temperature and irradiance.

2.74 Solar Cell

The basic photovoltaic device which generates electricity when exposed to sunlight.

2.75 Solar Cell Area

The entire frontal area (cm^{2}) of the solar cell, including the cell grid.

2.76 Solar Elevation (θ)

Angle between the direct solar beam and the horizontal plane (degrees).

2.77 Solar Simulator (Photovoltaic)

A light source capable of irradiating a photovoltaic device to the standard of irradiance uniformity and spectral match required for test purposes.

2.78 Source Circuit (String, Series Branch)

A number of modules and/or parallel modules connected in varies to provide of cover at the system voltage.

2.79 Spectral (Spectro) Irradiance Distribution

Spectral (spectro) irradiance plotted as a function of wavelength (Wm^{-2} μm^{-1}).

2.80 Spectral (Spectro) Radiometer

Equipment for the measurement of the spectral (spectro) irradiance distribution as a function of wavelength.

2.81 Spectral Response (Spectral Responsivity) Mismatch Error

The error introduced in the testing of a photovoltaic device, caused by mismatch between the relative spectral response (spectral responsivity) of the photovoltaic Test Sample and the phovoltaic Reference Cell as well as mismatch between the test irradiance spectrum and the reference spectral (spectro) irradiance distribution.

2.82 Stand-Alone System

A photovoltaic system that is operated independently of the utility lines.

2.83 Standard Reporting Conditions

A fixed set of conditions to which the electrical performance data of device is translated from the set of actual test conditions.

2.84 Standard Operating Conditions (SOC)

Irradiance = 1 000 Wm^{-2} with the reference solar spectral (spectro) irradiance distribution. Cell Temperature — Nominal Operating Cell Temperature (NOCT).

2.85 Spectral Response (Spectral Responsivity) (Absolute) ($S \lambda$)

The short-circuit current density generated by unit irradiance at a particular wavelength (Aw^{-1}), plotted as a function of wavelength*.

2.86 Spectral Response (Spectral Responsivity) (Relative) ($S \lambda$ rel)

The spectral response normalized to unity at wavelength of maximum response*.

2.87 Standard Test Conditions (STC)

Irradiance = 1 000 Wm^{-2} with the reference solar spectral irradiance distribution and a cell temperature of 25 ± 2°C.

2.88 Sub-array

That part of an array assembly that can be considered as a unit and whose output is some fraction of the array output.

2.89 Thermal Sub-system

A sub-system which receives thermal energy from the array sub-system. The thermal energy may be utilized for a thermal load application or dissipated.

2.90 Time Constant

The time required for a radiometer or photovoltaic device to attain 63·2 percent of its steady state value after a step change of irradiance.

2.91 Turbidity ($\propto_{D\lambda}$)

The reduced transparency of the atmosphere, caused by absorption and scattering of radiation by solid or liquid particles, other than clouds, held in suspension.

NOTE — As defined by Angstrom, the turbidity of the atmosphere is related to t, the extinction coefficient at a wavelength of 1 000 nm (normally called the 'turbidity coefficient') and to, the wavelength exponent in the expression for the aerosol extinction function:

$$\propto_{D\lambda} = t \cdot \lambda^{\epsilon}$$

't' values less than 0·10 denote a very clear condition, whereas values greater than 0·20 a distinctly hazy condition. The average value of ϵ which is dependent on the particle size distribution, was assumed by Angstrom to be approximately 1·3.

2.92 Utility Interactive System

A photovoltaic system capable of operating in parallel with and supplying power to the utility line.

2.93 Voltage Temperature Coefficient (β)

The change of the open circuit voltage of a photovoltaic device per degree celsius change of cell temperature.

NOTE — This coefficient varies with irradiance and to a lesser extent with temperature.

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*The term 'response' is commonly used. Strictly speaking 'responsivity' is the correct term.

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